5

Air Surveillance Monitoring

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Introduction

Lawrence Livermore National Laboratory performs air surveillance monitoring to evaluate its compliance with local, state, and federal laws and regulations and to ensure that human health and the environment are protected from hazardous and radioactive air emissions. Federal environmental air quality laws and U.S. Department of Energy (DOE) regulations include Title 40 of the *Code of Federal Regulations* (CFR) Part 61, the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) section of the Clean Air Act, and applicable portions of DOE Orders 5400.1 and 5400.5. The *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. DOE 1991) provides the guidance for implementing DOE Orders 5400.1 and 5400.5. In general, the constituents for which LLNL monitors are at levels far below the regulatory standards.

LLNL conducts surveillance monitoring of ambient air to determine if airborne radionuclides or hazardous materials are being released by Laboratory operations, what the concentrations are, and what the trends are in the LLNL environs. In the air monitoring program, LLNL collects particles on filters and chemically traps vapors on a collection medium. Concentrations of various airborne radionuclides (including particles and tritiated water vapor) and beryllium are measured at the Livermore site, Site 300, and at off-site locations throughout the Livermore Valley and in the City of Tracy. In addition, some point sources and diffuse, or nonpoint sources, are monitored to fulfill NESHAPs requirements (Gallegos et al. 2000).

Methods

Several monitoring networks were established for surveillance of air particulates and tritium in the environs of LLNL and Site 300, as well as in the surrounding Livermore Valley and in the City of Tracy. The sampling locations for each monitoring network are listed in **Table 5-1** and shown on **Figures 5-1**, **5-2**, and **5-3**. All monitoring networks use continuously operating samplers. The radiological high-volume sampling networks use glass-fiber filters; the beryllium high-volume networks use cellulose filters; and the low-volume network uses Millipore filters. The collection medium for tritium is silica gel.

Particulate filters are changed each week at all locations, and tritium samples are changed every two weeks. Duplicate quality control samplers operate in parallel with the permanent sampler at a given site, and these samples are analyzed to confirm results.

Air Particulate Sampling Locations

All air samplers are positioned to provide reasonable probability that, if there were any significant concentration of radioactive or beryllium effluents from LLNL operations, it would be detected.

The Livermore site radiological air surveillance sampling network (see **Figure 5-1**) consists of seven samplers at the perimeter with one (CRED) serving as the sitewide maximally exposed individual (SW-MEI) for NESHAPs reporting purposes. CRED is also located in the southeast quadrant in an area of known plutonium contamination attributed to historic operations, which included the operation of solar evaporators for plutonium-containing liquid waste.

The Livermore Valley network (see **Figure 5-2**) consists of air particulate samplers located in all compass directions from the Livermore site. For the purposes of data analysis, four samplers (FCC, FIRE, HOSP, and CHUR) located in the least prevalent wind directions are considered to be upwind or representative of background locations. An additional upwind sampler is located in another area of special interest, the Livermore Water Reclamation Plant (LWRP), because of a 1967 and earlier plutonium releases to the sanitary sewer system with subsequent soil contamination and potential resuspension (see the "Livermore Valley Surface Soil Results" section of Chapter 10 for a discussion of this). Four samplers (PATT, ZON7, TANK, and AMON) are located in the most prevalent downwind directions that are considered most likely to be affected by Laboratory operations.

Livermore site beryllium monitoring continued in 2000 at the six perimeter locations (see **Figure 5-1**). To satisfy beryllium reporting requirements and determine the effects of the Laboratory's beryllium operations, LLNL conducted a technical assessment of the beryllium monitoring locations at Site 300 in 1997. Although there is no requirement to sample for beryllium at Site 300, as a best management practice, LLNL has decided to continue beryllium monitoring at three locations on site (801E, EOBS, GOLF) and at one location in the City of Tracy (TFIR) (see **Figure 5-3**).

The Site 300 radiological air particulate monitoring network includes eight sampling units placed around the site boundary and near on-site firing tables and one in downtown Tracy (see **Figure 5-3**). Due to the remoteness of Site 300 and the difficulties with weekly access, monitoring sites were chosen based on safety, power, and access considerations. A new location, identified as COHO, was added in April 2000 and serves as the

Table 5-1. Sampling locations listed by monitoring network

High-volume radiological (glass fiber filters)	High-volume beryllium (cellulose filters)	Low-volume gross alpha and beta (millipore filters)	Tritium (silica gel)
Livermore site			
CAFE	CAFE		B292[a]
COW	COW		B331[a]
CRED[a]	MESQ		B514[a]
MESQ	MET		B624[a]
MET	SALV		CAFE
SALV	VIS		COW
VIS			MESQ
			MET
			POOL
			SALV
			VIS
Livermore Valley			
AMON		FCC	AMON
CHUR		HOSP	FIRE
FCC			HOSP
FIRE			VET
HOSP			XRDS
LWRP			ZON7
PATT			
TANK			
ZON7			
Site 300			
801E	801E		COHO[b]
COHO[b]	EOBS		
ECP	GOLF		
EOBS			
GOLF			
NPS			
WCP			
WOBS			
Site 300 off site			
TFIR	TFIR		PRIM[b]

a These locations are in areas of diffuse sources and are monitored to fulfill NESHAPs requirements.

b Location PRIM was removed January 26, 2000. Replacement location COHO was added April 2000.

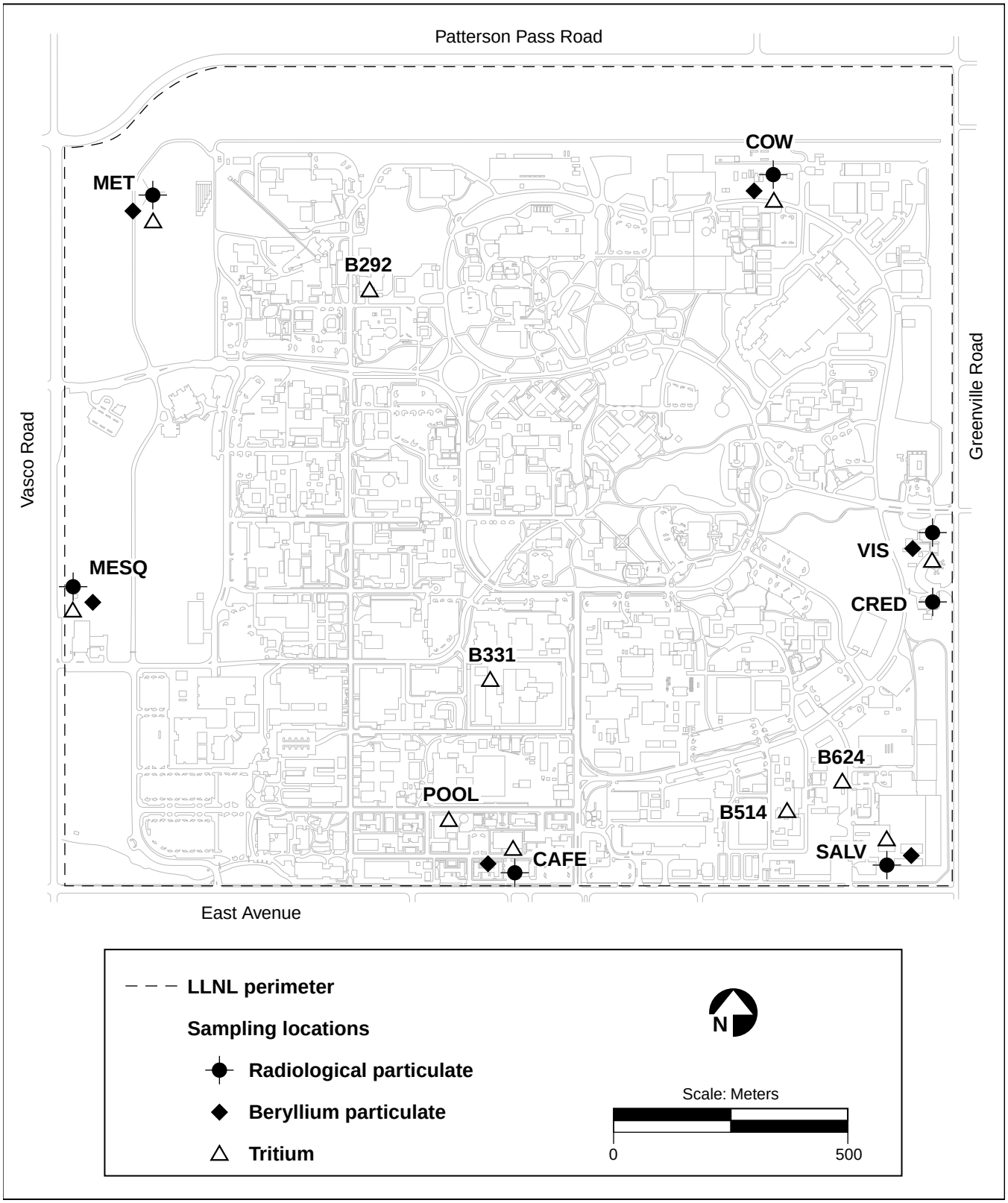

Figure 5-1. Air particulate and tritium sampling locations on the Livermore site, 2000

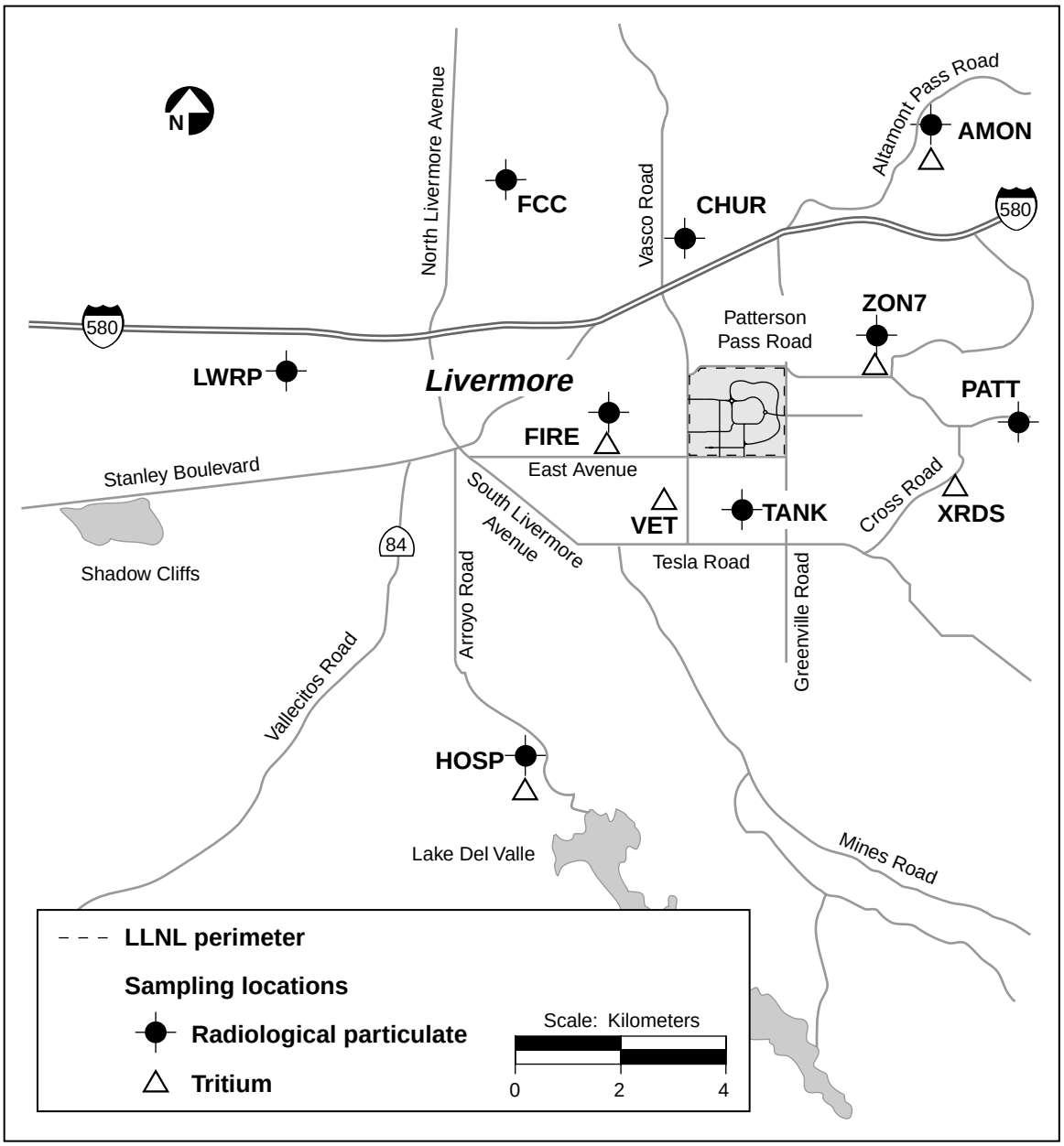

Figure 5-2. Air particulate and tritium sampling locations in the Livermore Valley, 2000

SW-MEI for NESHAPs reporting purposes. In addition to air particulate, air tritium is also analyzed at COHO.

Two sampling systems were added in July 1997 as part of the new low-volume radiological air surveillance sampling network. The samplers are situated at the FCC and HOSP locations, sites that are generally upwind of the Livermore site. The results are used to establish background levels of gross alpha and beta activity for direct comparison to results from the air effluent samplers (see Chapter 4). The sampling systems are very similar to the air-effluent samplers used in facilities,

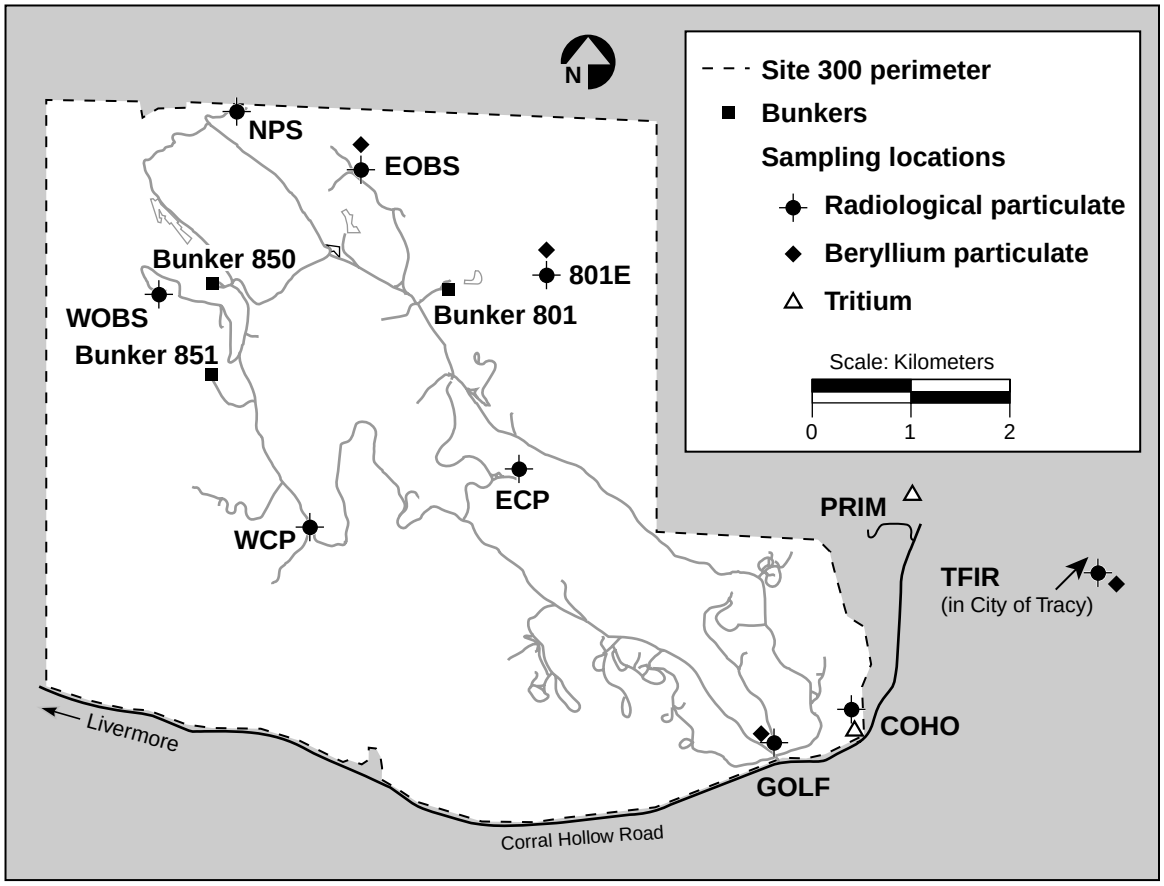

Figure 5-3. Air particulate and tritium sampling locations at Site 300 and off-site, 2000

including sampling system design, sampler operation, filter media, sample tracking, sample analysis, and processing of results.

Tritium Sampling Locations

LLNL also maintains 11 continuously operating, airborne tritium samplers on the Livermore site (see Figure 5-1), 6 samplers in the Livermore Valley (see Figure 5-2), and 1 sampler at Site 300 (see Figure 5-3) to assess historical and current activities that influence environmental impacts. Four of the Livermore site locations (B331, B292, B514, and B624) monitor diffuse tritium emissions.

Radiological Analysis

As outlined in *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. DOE 1991), gross alpha and gross beta air filter results are used as trend indicators; specific radionuclide analysis is done for plutonium, uranium, and gamma emitters. Radiological analytical results are reported as a measured concentration per volume of air. When the activity is less than the minimum detection concentration (MDC) the calculated value is reported (see Chapter 14 for further details). Particle size distributions are not determined because the estimated effective dose equivalent to the maximally exposed individual (from the total particulate) is well below

the 0.01-mSv (1-mrem) allowable limit as discussed in the above-mentioned environmental regulatory guide.

In January 2000, there was a change in the laboratory performing the air particulate analysis. This change resulted in an increase in the detection limit for plutonium, uranium, and gamma isotopes; however, all detection limits are adequate for determining environmental and health concerns. Gross alpha and gross beta activities are determined by gas-flow proportional counting; plutonium and uranium isotopes by alpha spectrometry; gamma emitters by gamma spectroscopy; and tritium by liquid scintillation. Further details of the surveillance monitoring methods are included in Chapter 5, Data Supplement.

Results

This section discusses the air monitoring results from all air surveillance locations at the Livermore site, Site 300, and all off-site surveillance locations.

In April 1997, the radiological air particulate sampling filter media were changed from cellulose to glass fiber; however, blank glass-fiber filters contain nontrivial amounts of some naturally occurring radiological isotopes (Althouse 1998) including uranium-235, uranium-238, potassium-40, radium-226, radium-228, and thorium-228. In fact, the amounts of these naturally occurring isotopes contained in these filters is often greater than the amounts of the isotopes being filtered from the air. LLNL adjusts the gross measured concentrations of these isotopes according to U.S. Environmental Protection Agency (EPA) procedures (Eadie and Bernhardt 1976). LLNL staff subtracts the appropriate blank filter content from the gross analytical result to obtain a corrected net result. This subtraction of the background filter content, coupled with the higher detection limit and uncertainty, resulted in highly variable uranium-235 to uranium 238 ratios. Historically, these ratios have been used to determine the presence of naturally occurring uranium; however, this variability made the ratio results useless. Therefore, the ratios are not reported.

Livermore Site

Airborne Radioactivity

Table 5-2 summarizes the monthly gross alpha and gross beta results for the LLNL perimeter, Livermore Valley, Site 300, and Site 300 off-site sampling locations. Detection frequencies, median concentrations, interquartile ranges (IQR), and maximum concentration values for each network are included. (See Data Supplement Tables 5-1, 5-2, and 5-3 for detailed location results for all high-volume networks for gross alpha and gross beta concentrations.)

Typical gross alpha activity (median value) for the LLNL perimeter is 6.9×10^{-5} Bq/m^3 (1.9×10^{-15} Ci/m^3); for both the upwind and downwind Livermore Valley stations, the value is 6.8×10^{-5} Bq/m^3 (1.8×10^{-15} Ci/m^3). Typical gross beta activity (median value) for the LLNL perimeter is 1.9×10^{-4} Bq/m^3 (5.1×10^{-15} Ci/m^3); for the upwind Livermore Valley stations, the value is 4.1×10^{-4} Bq/m^3 (1.1×10^{-14} Ci/m^3); and for the downwind Livermore stations, the value is 4.0×10^{-4} Bq/m^3 (1.1×10^{-14} Ci/m^3). Negative values occur when the activity of the analytical background is higher than the activity on the filters being analyzed. The primary sources of the alpha and beta activities are the naturally occurring radioisotopes of uranium and thorium, and any residual fallout from atmospheric weapons testing and the 1986 Chernobyl reactor accident. The monthly median gross alpha and gross beta concentrations are plotted in **Figures 5-4** and **5-5**, respectively. The gradual increase in gross alpha and gross beta activity throughout the summer was most likely caused by

Table 5-2. Gross alpha and gross beta concentration in air particulate samples summarized by month, 2000

Month	Gross alpha (10^{-6} Bq/m^3)				Gross beta (10^{-6} Bq/m^3)			
	Detection frequency [a]	Median	IQR [b]	Maximum	Detection frequency[a]	Median	IQR[b]	Maximum
LLNL perimeter locations								
Jan	25/30	64.6	70.9	396	30/30	483	227	1830
Feb	17/28	29.5	26.4	84.4	28/28	228	98.0	463
Mar	11/28	20.9	25.8	50.5	28/28	278	61.8	423
Apr	32/35	52.8	51.8	132	35/35	308	181	530
May	23/28	33.0	27.7	87.6	28/28	254	174	704
Jun	19/28	45.5	44.5	126	28/28	371	138	528
Jul	35/35	80.2	33.2	132	35/35	312	116	506
Aug	28/28	76.2	28.0	124	28/28	387	65.3	491
Sep	35/35	123	47.3	181	35/35	711	160	1020
Oct	25/28	76.7	48.9	163	28/28	637	217	760
Nov	27/27	99.3	56.7	259	24/24	780	862	1670
Dec	24/24	147	145	351	28/28	937	548	2060
Livermore Valley upwind locations								
Jan	16/20	54.4	84.6	309	20/20	431	236	1460
Feb	14/16	30.2	10.7	57.0	16/16	237	117	455
Mar	8/16	26.4	13.6	38.0	16/16	272	50.8	414
Apr	18/20	50.0	36.8	88.8	20/20	296	120	573
May	8/16	25.6	32.5	103	15/16	216	128	694
Jun	13/16	49.4	40.4	107	16/16	384	126	530
Jul	16/18	78.4	35.9	122	18/18	314	138	460
Aug	16/16	86.1	11.8	191	16/16	416	83.0	633
Sep	20/20	125	34	201	20/20	711	163	971
Oct	14/16	85.2	36.9	117	16/16	627	130	746
Nov	16/16	99.4	61.9	150	16/16	1040	902	1820
Dec	16/16	157	169	347	16/16	1110	695	1970
Livermore Valley downwind locations[c]								
Jan	23/25	62.2	52.6	385	25/25	422	286	1750
Feb	14/20	35.2	26.2	75.1	20/20	268	142	429
Mar	12/20	31.3	9.65	48.1	20/20	281	102	378
Apr	21/25	58.6	58.6	117	25/25	341	158	542
May	16/20	35.7	30.5	98.0	20/20	272	197	709
Jun	15/20	45.6	37.9	77.8	20/20	383	101	591
Jul	25/25	72.0	26.2	132	24/24	333	104	522
Aug	18/18	99.0	33.7	149	16/16	445	65.5	544
Sep	20/20	134	59.3	205	20/20	678	129	1060
Oct	16/16	78.5	40.6	148	16/16	631	188	769
Nov	16/16	92.7	55.8	154	16/16	1040	901	1750
Dec	16/16	125	149	380	16/16	1000	1140	1960

Table 5-2. Gross alpha and gross beta concentration in air particulate samples summarized by month, 2000 (continued)

Month	Gross alpha (10^{-6} Bq/m^3)				Gross beta (10^{-6} Bq/m^3)			
	Detection frequency [a]	Median	IQR [b]	Maximum	Detection frequency[a]	Median	IQR[b]	Maximum
Site 300 locations [d]								
Jan	31/35	77.3	78.0	374	35/35	507	269	1620
Feb	17/28	30.6	46.7	111	29/29	226	198	566
Mar	16/27	32.3	20.4	59.5	27/27	341	98.5	468
Apr	32/41	54.4	50.6	137	40/41	370	198	666
May	34/37	44.8	29.3	94.8	36/36	338	207	741
Jun	29/36	55.5	35.1	84.3	36/36	460	228	619
Jul	42/43	92.9	23.9	159	42/44	406	145	755
Aug	37/37	103	34.7	163	37/37	489	85.0	681
Sep	44/44	123	47.0	248	43/43	818	353	1110
Oct	30/37	91.9	65.2	181	37/37	678	325	1070
Nov	35/36	90.6	55.3	210	36/36	931	763	2080
Dec	36/36	152	134	331	36/36	1160	540	1940

a Detection frequency is the number of samples with calculated results greater than the uncertainty divided by the number of samples.

b IQR = Interquartile range

c Livermore Valley downwind locations include data from the special interest location LWRP, see **Figure 5-2.**

d Site 300 locations includes data from one off-site location (TFIR), see **Figure 5-3.**

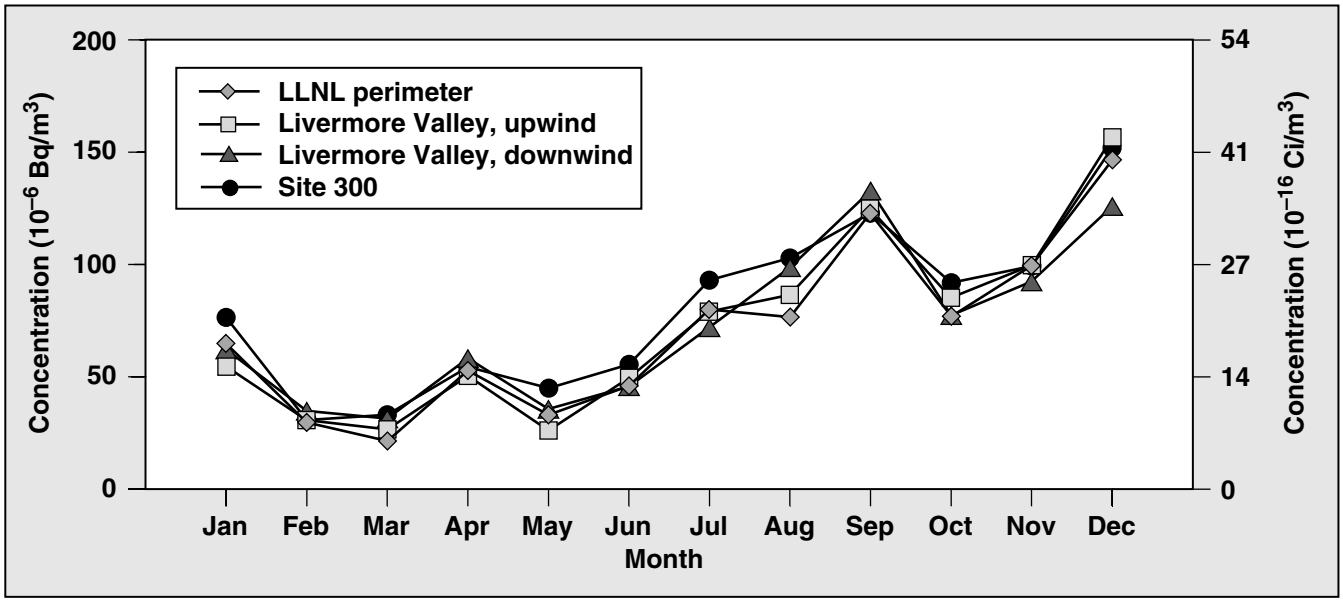

Figure 5-4. Monthly median gross alpha concentrations in particulate air samples from the LLNL perimeter, Livermore Valley, and Site 300 sampling locations, 2000

an increase in resuspension of soils that occurs during the dry season. December values are also elevated because of low rainfall during that month. These data follow a similar pattern to the low-volume gross alpha and gross beta data.

Gamma-emitting radionuclide concentrations in air that contribute to the activity in the Livermore site perimeter samples are summarized in **Table 5-3**. (See Data Supplement Table 5-4 for monthly gamma activity data.) Of the nuclides identified, all were naturally occurring, with the exception of cesium-137. The primary source of cesium-137 is long-term global fallout and fallout resuspension.

By analyzing air samples for gamma-emitting radionuclides, LLNL verifies that there is no evidence of a release of the small inventories of mixed fission products and radiochemical tracers used at LLNL and also obtains baseline data on global fallout. The Derived Concentration Guides (DCGs) for these radionuclides are shown in **Table 5-3**. For air, DCGs specify the concentrations of radionuclides that could be inhaled continuously 365 days a year without exceeding the DOE primary radiation protection standard for the public, which is 1 mSv/y (100 mrem/y) effective dose equivalent (DOE Order 5400.5). (Chapter 13 provides an explanation of this and other units of dose.) **Table 5-3** also presents the percent of the DCGs, which demonstrates that the level of gamma activity present in air at the Livermore site perimeter was far below the DCGs.

Table 5-4 shows the concentrations of airborne plutonium-239+240 on air filters from the LLNL perimeter locations. In September, the plutonium concentrations reported were above the minimum detectable limit for nearly all locations (including a trip blank sample). While many of these values exceeded the action level established by the *Environmental Monitoring Plan* (Tate et al. 1999), none of them exceeded the DCG. However, because the concentrations were unusually high, the analytical laboratory was asked to investigate the possibility of laboratory contamination. The analytical laboratory confirmed that the high values were likely the result of internal laboratory contamination and has since implemented protocol to reduce the chance of reoccurrance. Six similar samples, colocated at the onsite LLNL locations, were subsequently analyzed by another laboratory using the same methodology. Of these six samples, only one sample (SALV) result was above the detection limit and its value was six times less than the original value. Both data sets are shown in Table 5-5, Data Supplement. For conservative measures, and because only onsite colocated samples were available for reanalysis, all summary statistics were performed using the higher of the two values.

Data Supplement Table 5-5 shows the monthly data by location. The highest concentration was registered at location CRED in September 2000; the concentration value is reported as 5.8×10^{-7} Bq/m^3 (1.6×10^{-17} Ci/m^3), which represents 0.025% of the DCG. The highest median concentration onsite, at location SALV, was 1.5×10^{-8} Bq/m^3 (4.1×10^{-19}Ci/m^3), which is similar to that for the previous year.

Table 5-4 also shows the detection frequency, median concentration, IQR, maximum concentration, and percent of DCG for the concentration of plutonium on air filter samples collected in the Livermore Valley. The highest concentration was registered at location FCC in October; the value of 3.7×10^{-6} Bq/m^3 (1.0×10^{-16} Ci/m^3), which exceeded the action level established by the *Environmental Monitoring Plan*, represents 0.50% of the DCG. Because this sampling location is upwind of LLNL and plutonium activity is unlikely, this data was investigated. Plutonium analysis using the new laboratory is performed by digesting a filter, removing an aliquot from the digestate,

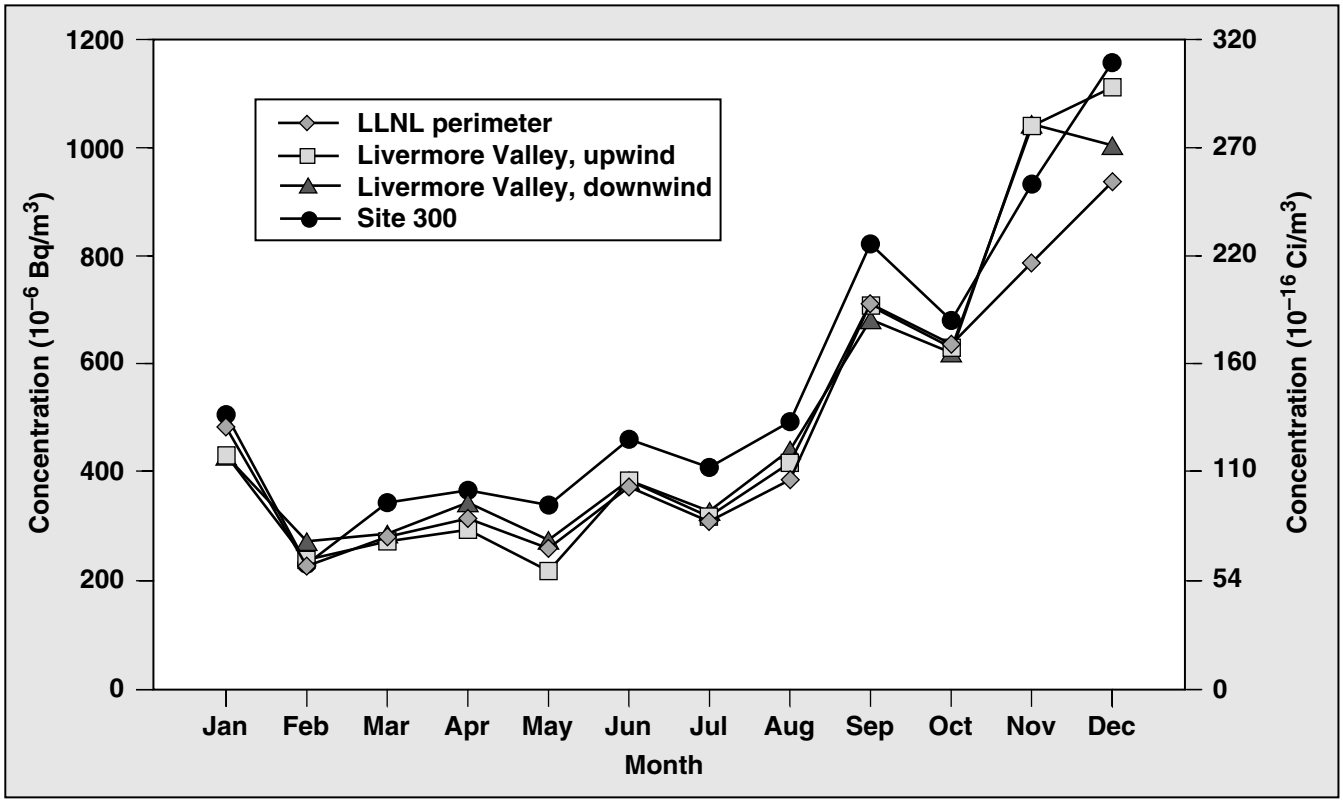

Figure 5-5. Monthly median gross beta concentrations in particulate air samples from the LLNL perimeter, Livermore Valley, and Site 300 sampling locations, 2000

Table 5-3. Gamma activity in air particulate samples, Livermore site perimeter and Site 300, 2000

	^{7}Be	^{137}Cs	^{40}K	^{22}Na	^{226}Ra	^{228}Ra	^{228}Th
	(10^{-3}Bq/m^3)	(10^{-6} Bq/m^3)					
Livermore perimeter							
Median	0.87	–0.051	–1.1	0.46	–0.89	–0.68	–0.12
Interquartile range	0.48	0.43	18	0.35	2.0	1.9	3.6
Maximum	1.7	1.3	32	1.4	3.0	2.3	4.7
Percent of DCG[a]	5.8×10^{-5}	8.7×10^{-6}	3.2×10^{-6}	1.2×10^{-6}	2.7×10^{-3}	6.2×10^{-3}	0.31
Site 300							
Median	0.91	0.018	–0.85	0.26	–1.3	–1.01	–0.22
Interquartile range	0.98	0.60	14	0.40	1.7	3.6	2.1
Maximum	2.1	1.1	23	0.78	1.4	1.5	1.1
Percent of DCG[a]	6.0×10^{-5}	1.2×10^{-7}	7.0×10^{-5}	7.0×10^{-7}	1.3×10^{-3}	4.1×10^{-3}	0.073
DCG (Bq/m^3)	1.5×10^{3}	15	33	37	0.11	0.037	1.5×10^{-3}

a Percent of Derived Concentration Guide (DCG) is calculated from the median value unless median value is negative. When median value is negative, the maximum value is used.

Table 5-4. Plutonium-239+240 activity in air particulate samples (10^{-9} Bq/m^3), 2000

Sampling locations [a]	Detection frequency [b]	Median	Interquartile range	Maximum	Percent of DCG [c]
LLNL perimeter locations					
CAFE	3/13	9.07	9.30	108	1.23×10^{-3}
COW	7/13	8.25	7.82	120	1.11×10^{-3}
CRED	5/12	6.92	18.3	582	9.34×10^{-4}
MESQ	5/13	8.56	17.2	145	1.16×10^{-3}
MET	2/13	3.93	7.58	57.7	5.31×10^{-4}
SALV	7/13	15.2	25.5	183	2.05×10^{-3}
VIS	4/13	8.36	19.0	78.5	1.13×10^{-3}
Livermore Valley upwind locations					
CHUR	7/12	8.98	15.7	206	1.21×10^{-3}
FCC	5/12	3.92	15.9	3720	5.30×10^{-4}
FIRE	5/12	0.00	15.6	572	7.73×10^{-2}
HOSP	2/12	2.88	15.1	409	3.89×10^{-4}
LWRP	7/12	9.03	15.6	88.9	1.22×10^{-3}
Livermore Valley downwind locations					
AMON	5/5	11.1	23.8	34.8	1.50×10^{-3}
PATT	6/12	9.25	22.1	159	1.25×10^{-3}
TANK	3/12	6.81	18.2	215	9.20×10^{-4}
ZON7	5/12	5.79	15.8	87.7	7.82×10^{-4}
Site 300 on-site location composite					
S300 composite	2/12	1.34	4.34	18.6	1.80×10^{-4}

a See **Figures 5-1**, **5-2**, and **5-3** for sampling locations.

b Detection frequency is the number of samples with the calculated results greater than the uncertainty divided by the number of samples.

c DCG = Derived Concentration Guide of 7.4 x 10^{-4} Bq/m^3 for plutonium-239+240 activity in air. Percent DCG is calculated on the median concentrations unless median value negative. When median value is negative or zero, the maximum value is used.

then plating the plutonium on a planchet for counting. This sample was recounted using another aliquot from the same digestate and the value was confirmed. It is believed that there was laboratory contamination during the digesting processing of the filter and therefore, the recount also detected plutonium. An undigested portion of this sample was also sent to another laboratory where plutonium was not detected. The remainder of 2000 data from FCC was less than the detection limit. See Data Supplement Table 5-6 for monthly data.

Figure 5-6 shows the annual median concentrations of plutonium-239+240 for locations SALV (on-site) and FCC (off-site) from 1982 to 2000. Location FCC represents a typical upwind background location, and SALV represents a typical

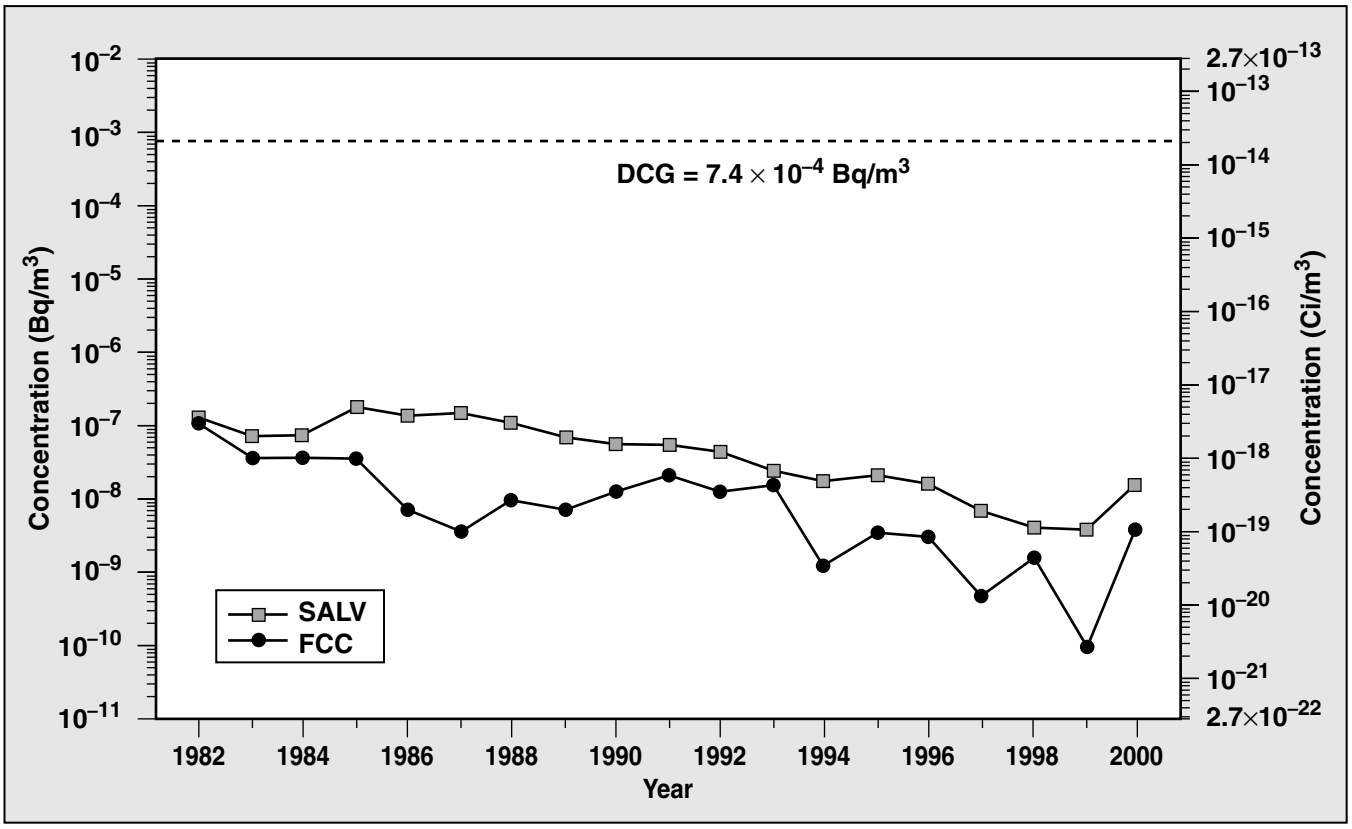

Figure 5-6. Annual median plutonium-239+240 concentrations in air particulate samples at two locations, SALV (on-site) and FCC (upwind, off-site), 1982-2000

perimeter location. The annual median concentration for FCC was 3.9×10^{-9} Bq/m^3 (1.1×10^{-19} Ci/m^3); this value includes the high value for October discussed previously.

Figure 5-6 uses a log scale and, for the years in which a negative median concentration was calculated, the positive value closest to the median was plotted. The higher values in the past at SALV may be attributed to historical activities at LLNL. The general downward trend at both locations is likely the result of decreasing residual global fallout. The increase at both locations this year is most likely the result of the change in the analytical laboratory.

As the result of a network assessment, starting January 2000, Livermore perimeter site-specific uranium analysis was eliminated because there are no significant sources of uranium on-site. Instead a composite from six perimeter locations (CAFE, COW, MESQ, MET, SALV, and VIS) is created to determine uranium activities at LLNL. These data are shown in **Table 5-5**. The maximum uranium-235 and uranium-238 concentration was less than 0.01% of the DCG for each isotope.

The low-volume radiological air sampling locations FCC and HOSP have an annual median for gross alpha and gross beta activity of 4.1×10^{-5} Bq/m^3 (1.1×10^{-15} Ci/m^3) and 4.4×10^{-4} Bq/m^3 (1.2×10^{-14} Ci/m^3), respectively. (See Data

Table 5-5. Uranium mass concentration in air particulate samples, 2000

Sampling location[a]	^{235}U[b] (10^{-7} μg/m^3)	^{238}U[c] (10^{-5} μg/m^3)
801E		
Median	1.32	3.79
Interquartile range	8.47	4.05
Maximum	16.1	17.7
Percent of DCG [d]	2.81×10^{-4}	1.26×10^{-2}
COHO		
Median	0.773	0.952
Interquartile range	7.53	7.92
Maximum	8.30	5.79
Percent of DCG [d]	1.64×10^{-4}	3.17×10^{-3}
ECP		
Median	2.70	3.06
Interquartile range	6.24	3.55
Maximum	13.6	13.5
Percent of DCG [d]	5.73×10^{-4}	1.02×10^{-2}
EOBS		
Median	1.42	3.71
Interquartile range	2.88	3.51
Maximum	33.0	44.6
Percent of DCG [d]	3.01×10^{-4}	1.24×10^{-2}
GOLF		
Median	1.67	3.98
Interquartile range	10.9	3.90
Maximum	25.0	35.0
Percent of DCG [d]	3.54×10^{-4}	1.33×10^{-2}
NPS		
Median	0.486	2.18
Interquartile range	5.64	2.06
Maximum	21.8	5.64
Percent of DCG [d]	1.03×10^{-4}	7.25×10^{-3}
TFIR		
Median	4.82	7.48
Interquartile range	4.60	4.15
Maximum	8.75	15.3
Percent of DCG [d]	1.03×10^{-3}	2.49×10^{-2}
WCP		
Median	–0.782	2.96
Interquartile range	3.88	4.94
Maximum	5.42	5.73
Percent of DCG [d]	1.15×10^{-3}	9.87×10^{-3}
WOBS		
Median	1.59	1.79
Interquartile range	7.40	3.60
Maximum	11.7	32.4
Percent of DCG [d]	3.38×10^{-4}	5.97×10^{-3}
Livermore Composite		
Median	–4.24	–4.85
Interquartile range	7.23	8.98
Maximum	9.68	14.3
Percent of DCG [d]	2.06×10^{-3}	4.77×10^{-2}

a See **Figures 5-1** and **5-3** for sampling locations.

b Derived Concentration Guide = 0.047 μg/m^3 for uranium-235 activity in air. Uranium-235 activities in Bq/m^3 can be determined by dividing the weight in μg/m^3 by 12.5.

c Derived Concentration Guide = 0.3 μg/m^3 for uranium-238 activity in air. Uranium-238 activities in Bq/m^3 can be determined by dividing the weight in μg/m^3 by 80.3.

d Percent of Derived Concentration Guide (DCG) is calculated from the median value. When median value is negative, the percent DCG is calculated from the maximum value.

Supplement Tables 5-8 and 5-9 for monthly median data.) These gross alpha values are similar to those reported from the high-volume sampling systems at the same locations.

Table 5-6 shows the median concentrations of tritiated water vapor for the Livermore Valley sampling locations. (See Data Supplement Table 5-10 for biweekly data for each location.) The highest annual median concentration was observed at location ZON7**.** At approximately 1.4×10^{-2} Bq/m^3 (3.8×10^{-13} Ci/m^3), this concentration represents 0.0004% of the DCG. The highest biweekly concentration was observed in July at ZON7. If it were a yearly average, this concentration of 8.9×10^{-2} Bq/m^3 (2.4×10^{-12} Ci/m^3) would be 0.002% of the DCG. The 2000 tritium values were lower than those reported last year because of lower emissions from the Tritium Facility (Building 331).

Table 5-6. Tritium in air samples, 2000

Sampling location[a]	Detection frequency[b]	Median (10^{-3} Bq/m^3)	IQR[c] (10^{-3} Bq/m^3)	Maximum (10^{-3} Bq/m^3)	Percent of DCG[d]	Median dose (mSv)[e]
Livermore Valley locations						
AMON	3/17	7.99	6.88	16.8	2.2×10^{-4}	1.7×10^{-6}
FIRE	3/26	5.70	7.86	27.1	1.5×10^{-4}	1.2×10^{-6}
HOSP	0/24	0.762	8.41	27.6	2.1×10^{-5}	1.6×10^{-7}
VET	5/23	7.84	13.5	29.5	2.1×10^{-4}	1.6×10^{-6}
XRDS	0/7	0.755	7.35	10.5	2.0×10^{-5}	1.6×10^{-7}
ZON7	9/24	14.1	10.6	89.2	3.8×10^{-4}	2.9×10^{-6}
Livermore perimeter locations						
CAFE	21/26	40.5	42.2	129	1.1×10^{-3}	8.4×10^{-6}
COW	22/23	33.6	22.7	1370	9.1×10^{-4}	7.0×10^{-6}
MESQ	15/26	20.9	17.0	66.2	5.6×10^{-4}	4.3×10^{-6}
MET	11/23	17.9	22.3	186	4.8×10^{-4}	3.7×10^{-6}
POOL	26/26	76.6	74.7	343	2.1×10^{-3}	1.6×10^{-5}
SALV	18/23	27.3	21.6	55.1	7.4×10^{-4}	5.7×10^{-6}
VIS	24/24	47.4	31.3	248	1.3×10^{-3}	9.8×10^{-6}
Diffuse on-site sources locations						
B292	19/23	55.1	38.1	137	1.5×10^{-3}	1.1×10^{-5}
B331	26/26	446	697	2100	1.2×10^{-2}	9.3×10^{-5}
B514	25/25	1850	1830	8470	5.0×10^{-2}	3.8×10^{-4}
B624	26/26	3280	2040	5920	8.9×10^{-2}	6.8×10^{-4}
Site 300 location						
COHO	0/25	–2.27	10.3	7.62	2.1×10^{-4}[f]	1.6×10^{-6}[g]

a See **Figures 5-1**, **5-2**, and **5-3** for sample locations.

b Detection frequency is the number of samples with results above the detection limit divided by the number of samples.

c IQR = Interquartile range

d DCG= Derived Concentration Guide of 3.7×10^3 Bq/m^3. Percent calculated from the median concentration.

e 1 mSv = 100 mrem

f The percent of DCG was determined by using the maximum value because the median value was negative.

g The dose was determined by using the maximum value because the median value was negative.

Table 5-6 also shows the median concentrations of tritiated water vapor that were observed at the Livermore site perimeter sampling locations. (See Data Supplement Table 5-11 for biweekly data.) The highest annual median concentration was observed at location POOL, which was 7.7×10^{-2} Bq/m^3 (2.1×10^{-12} Ci/m^3), or 0.002% of the DCG. The highest biweekly concentration, 1.4 Bq/m^3 (3.8×10^{-11} Ci/m^3), was observed in August at location COW. A transportainer containing tritium-contaminated waste was stored near the COW location for several days before being shipped offsite for disposal.

Diffuse sources of tritium on the Livermore site are monitored at air tritium sampling locations B292, B331, B514, and B624. **Table 5-6** shows the median concentrations of tritiated water vapor for these sampling locations. (See Data Supplement Table 5-12 for biweekly data.) The highest median concentration was observed at location B624. This concentration was 3.3 Bq/m^3 (8.9×10^{-11} Ci/m^3) and represents 0.09% of the DCG. The highest biweekly tritium concentration, 8.5 Bq/m^3 (2.3×10^{-10} Ci/m^3), was observed in April at location B514. If it were a yearly average, this concentration would represent 0.2% of the DCG.

The B514 sampling location is in a hazardous waste management area where tritium-contaminated waste is treated, and the B292 location is near an underground retention tank that had previously leaked. The concentrations in air at the B514 sampling location are variable because of the changing concentrations of tritium in the waste stream. The 2000 median concentrations at B292 and B514 are similar to the median concentrations in 1999.

The B331 location is near the Tritium Facility (Building 331), where LLNL personnel have reduced operations in recent years and performed significant inventory reduction and cleanup activities. During this process, tritium-contaminated equipment slated for disposal was stored in an area outside Building 331 before being sent to Hazardous Waste Management facilities. Although this area is no longer used for storage of tritium-contaminated equipment, Building 331 is still considered a diffuse source and monitoring will continue. During 2000, an estimated 1.9×10^{11} Bq (5.2 Ci) of tritium was released to the atmosphere outside Building 331.

Beryllium in Air

The median concentrations of airborne beryllium for the Livermore site perimeter sampling locations are shown in **Table 5-7**. (See Data Supplement Table 5-13 for monthly data.) The highest value of 38.2 pg/m^3 was found in the March composite at location MESQ. The median concentration for this location is 0.11% of the monthly ambient concentration limit (ACL) of 10,000 pg/m^3 established by the Bay Area Air Quality Management District (BAAQMD) and the EPA.

Figure 5-7 is a plot of the median beryllium concentration at the Livermore site perimeter from 1975 through 2000. The decrease in median concentration in 1993 and the increase in 1999 were the result of a change in the analytical laboratory used to perform this analysis. The overall median concentration from 1975 through 2000 was calculated to be 0.18% of the ACL. Unless there is a change in LLNL's operations, the beryllium levels are expected to remain unchanged.

Site 300

Airborne Radioactivity

Table 5-2 shows the detection frequency and the monthly gross alpha and gross beta median, IQR, and maximum for sampling locations at Site 300. (See Data Supplement Table 5-14 for monthly data.) The monthly median gross alpha and gross

Table 5-7. Beryllium in particulate samples for Livermore site perimeter and Site 300 locations, 2000

Sampling location[a]	Detection frequency[b]	Median (pg/m^3)	Interquartile range (pg/m^3)	Maximum (pg/m^3)
Livermore perimeter locations				
CAFE	11/12	16.4	11.4	28.2
COW	8/12	10.3	12.3	24.0
MESQ	11/12	11.1	8.81	38.2
MET	9/12	9.30	7.66	20.0
SALV	8/12	9.00	11.0	22.3
VIS	9/12	10.3	9.03	20.0
Site 300 locations				
801E	8/12	7.46	8.84	25.7
EOBS	5/12	4.82	7.36	11.7
GOLF	9/12	10.2	8.44	17.6
TFIR	8/9	15.9	16.7	30.4

a See **Figures 5-1** and **5-3** for sampling locations.

b Detection frequency is the number of samples with results above the detection limit divided by the number of samples.

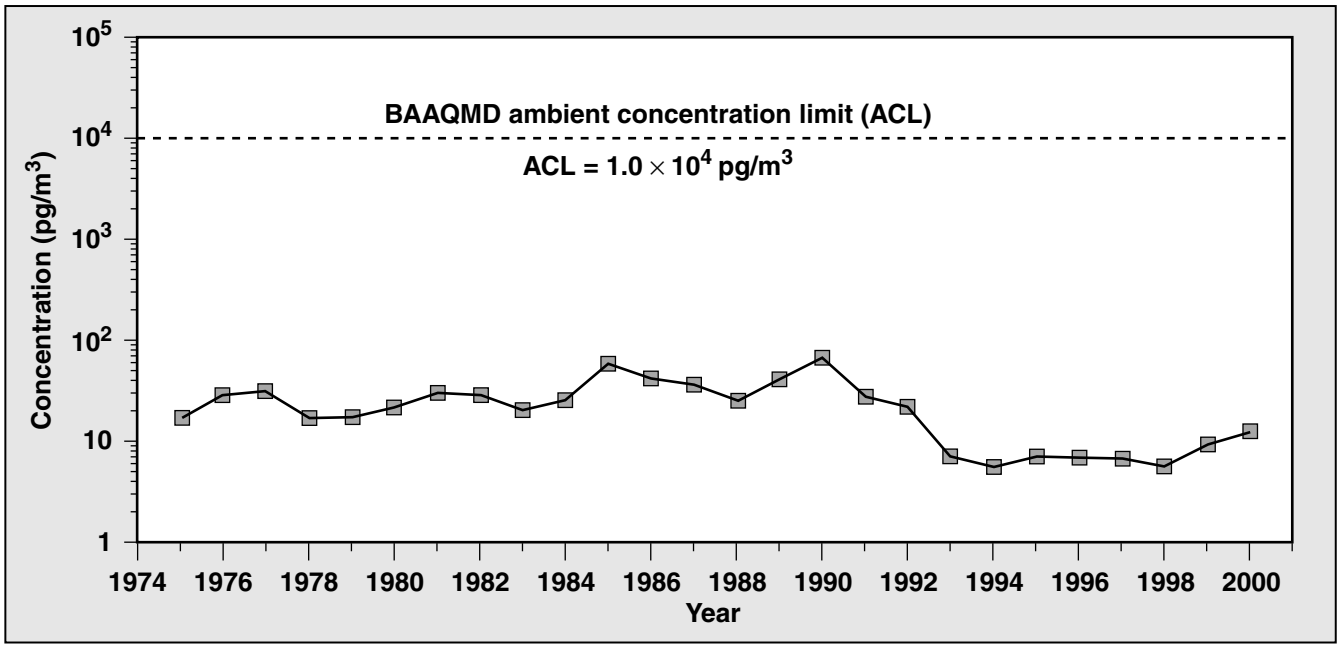

Figure 5-7. Median concentration of beryllium in air particulate samples taken at the Livermore site perimeter, 1975–2000

beta concentrations are shown in **Figures 5-4** and **5-5**. The Site 300 gross alpha and gross beta results show a similar pattern to those found at the Livermore site. The median gross alpha activity is 8.2×10^{-5} Bq/m^3 (2.2×10^{-15} Ci/m^3). The median gross beta activity is 5.0×10^{-4} Bq/m^3 (1.3×10^{-14} Ci/m^3). These values are similar to those obtained from previous monitoring data during the past several years.

The primary sources of observed gross alpha and gross beta activity are naturally occurring radioisotopes of uranium and thorium, their decay products, and any residual fallout from atmospheric weapons testing and the 1986 Chernobyl reactor accident.

Table 5-3 lists the annual median activities, detection frequencies, IQR, maximum, the percent of the DCG, as well as the DCG, of gamma-emitting radionuclides in samples from Site 300. (See Data Supplement Table 5-15 for monthly data.) All these radionuclides were measured at concentrations significantly below the DCGs. Of the nuclides identified, all are naturally occurring, with the exception of cesium-137. The primary source of cesium-137 normally is long-term global fallout and resuspension.

Table 5-4 shows the median concentration of plutonium-239+240 on air-filter samples collected from Site 300. (See Data Supplement Table 5-16 for monthly data.) The highest concentration of plutonium-239+240 was recorded in the April composite at a level of 1.9×10^{-8} Bq/m^3 (5.1×10^{-19} Ci/m^3), or 0.003% of the DCG.

As the result of a network assessment, and because Site 300 has uranium sources (from explosive testing and resuspension of this residue in these soils), the uranium analysis was expanded to all Site 300 locations (including TFIR). **Table 5-5** shows the median concentration of uranium-235 and uranium-238 for the air samples from the Site 300 network. (See Data Supplement Table 5-17 for monthly data.) The highest concentrations of uranium-235 (3.3×10^{-6} µg/m^3) and uranium-238 (4.5×10^{-4} µg/m^3) were observed in April at location EOBS. These concentrations represent less than 0.01% of the DCG for both isotopes.

Table 5-6 shows the median concentration of tritiated water vapor that was observed at the new sampling location (COHO) near Site 300. (See Data Supplement Table 5-18 for biweekly data.) The annual median concentration is -2.3×10^{-3} Bq/m^3 (-6.2×10^{-14} Ci/m^3). The maximum concentration at location COHO of 7.9×10^{-3} Bq/m^3 is 0.0002% of the DCG.

Beryllium in Air

The detection frequency, median concentration, IQR, and maximum concentrations of airborne beryllium for the Site 300 sampling locations are shown in **Table 5-7**. (See Data Supplement Table 5-19 for monthly data.) The highest beryllium concentration of 30.4 pg/m^3 occurred in September at location TFIR. The median concentration for this location is 0.16% of the federal and state ambient concentration limit, which is 10,000 pg/m^3.

Environmental Impact

The environmental impacts from both radioactive and nonradioactive effluents are described in this section.

Radioactive Materials

LLNL operations involving radioactive materials had little impact on radionuclide concentrations in ambient air during 2000. Radionuclide

concentrations in air at the Livermore site and in the Livermore Valley were well below the levels that would cause concern for the environment or public health according to existing regulatory standards.

The diffuse tritium sources at B292, B331, B514, and B624 had a localized effect; elevated concentrations such as those found at diffuse sources were not bound at perimeter or off-site locations.

The concentrations of radionuclides measured around Site 300 and in the City of Tracy were well below the levels that would cause concern for the environment or public health according to existing regulatory standards.

Nonradioactive Materials

The concentrations of beryllium at both sites can be attributed to resuspension of surface soil containing naturally occurring beryllium. Local soils contain approximately 1 ppm of beryllium, and the air of the Livermore area and the Central Valley typically contains 10 to 100 $\mu g/m^3$ of particulates. Using a value of 50 $\mu g/m^3$ for an average dust load and 1 ppm for beryllium content of dust, a conservative airborne beryllium concentration of 50 pg/m^3 can be predicted. The overall annual medians for the Livermore site and Site 300 are 11.5 pg/m^3 and 8.4 pg/m^3, respectively. These data are lower than predicted, well below standards, and do not indicate the presence of a threat to the environment or public health.